Rearing *Thyridopteryx ephemeraeformis* (Haw.) (Lep:. Psychidae)

The evergreen bagworm moth *Thyridopteryx ephemeraeformis* is one of the better known New World Psychidae. Its larvae are polyphagous, feeding on a vast range of plant material including Cupressacaea, Pinaceae, Poaceae, Asteraceae, Brassicaceae, Chenopodiaceae, Ericaceae, Fagaceae, Rosaceae and Salicaceae, among others. Consequently, it is of economic importance in the New World. Unusually for a New World species, the type locality is Great Britain. Wood, in his 1839 *Index Entomologicus*, figured Haworth's 1803 type specimen, which is now lost, under the vernacular name of "beltless clearwing" and stated that it was taken by Mr. Bolton in Yorkshire (presumably some time before 1803). It was not until 1841 that Edward Doubleday (Remarks on some North American Lepidoptera *Entomologist* **7**, 97-101) established that it is a denizen of the New World. Davis, in his authoritative *Bagworm Moths of the Western Hemisphere* (published by the Smithsonian Institution in 1964), gives an explanation for the inclusion of this species on the British list. The type specimen was most likely to have been collected by John Abbott in Georgia, then sent to Francillon, a London dealer in entomological specimens. Francillon is known to have mislabelled foreign material and sold it as British, so this specimen presumably found its way from him to Adrian Haworth who, describing it in 1803 (*Lepidoptera Britannica*), assigned it to the genus *Sphinx*. However, the possibility of its accidental import into Britain cannot be ruled out as the species pupates in mid summer but does not hatch until late autumn. Furthermore, it overwinters as an ovum in the female's case, so there would be scope for the importation of early stages from the New World, perhaps with plant material, even with the slow means of transportation available at that time.

Recently I have gained some experience in rearing this interesting bagmoth. On 10 March 2003 a colleague gave me around 100 newly hatched first instar larvae of *T. ephemeraeformis*. These originated from two female cases collected on 29 November 2002 by Gaden S. Robinson at the Lake of the Ozarks, Laurie, Missouri in the United States of America. As these larvae are polyphagous extreme care was taken while rearing them to ensure that none escaped. All waste material from the culture vessels was frozen at -80°C for two weeks or longer prior to disposal. This, and the fact that this species reproduces sexually (i.e. it is not parthenogenetic, as are some members of this family), ensured successful confinement.

First and second instar larvae were fed on soft new growth of *Thuja orientalis* (Linn.), a food plant not listed for this species by Davis (1964). Subsequent instars were fed on the coarser but easier obtained leyland cypress, *Cupressocyparis leylandii* (Dallim. & Jacks.). The various larval stadia (Table 1) were identified by virtue of the larvae fixing and sealing their cases prior to ecdysis. For this species, head capsule size was found to be unreliable for identifying the different instars, as male larvae are about 2/3 the size of female larvae in the same instar.

During instars 1 to 4 the larvae were uniformly dark purple/black in colour. Instar five was characterised by the presence of pale white/cream stripes and spots on the head and thoracic plates, which intensified in later instars so that eventually the

ground colour of these parts was pale, with variable dark brown/black spots. In the 9th instar the prothoracic plate had a group of three dark spots on each side, each group arranged in a triangular pattern (Figure 1). Observations showed that the final (10th) instar occurred within the larval case that had been previously fixed by the larva to the intended pupation site (usually a twig) with silk. No feeding occurred during this instar as the anterior end of the case had been closed and fixed to the food plant at the end of the 9th instar. Evidence for this 10th instar was provided by a case containing a 9th instar larva, found fixed prior to pupation on 5th June. This case was isolated in a Perspex box still fixed to its twig. Shortly after this the larva began reinforcing its case by laying down layers of pale flossy silk internally. This silk contracted with time, shrinking the case slightly as it did so. Impatient to know

Table 1. Approximate chronology of larval developmental stadia.

Larval instar	**Approximate dates when these developmental stages dominated the culture**
1	10 March (newly hatched)
2	20 March
3	7 April
4	20 April
5	1 May
6	16 May
7	24 May
8	30 May
9	15 June
10	15 July

what was happening inside, on 26 June I carefully cut the anterior end off the case to find that the larva had reversed its position so that it was now facing the posterior end of the case. Its anal claspers were visible at the cut anterior end of the case. On 1 July a cast larval skin (that of the 9th instar) was expelled from the cut end of the case, but the insect within was evidently still in the larval stage (now instar 10) as its anal end was projecting from the opened end of the case. On prodding it, the larva retreated within the case and remained there subsequently. Further reinforcement of the case with silk followed, then on the 15 July a second larval skin (that of the 10th instar) was expelled from the open anterior end of the case. Impatience again got the better of me, and on 22 July I carefully cut the case open length-wise to find it contained a live male pupa. This sequence of events occurred with other "pupating" larvae, no feeding taking place between instars 9 and 10. Therefore, it appears that this stadium is solely for the purpose of reinforcing the larval case prior to pupation.

During the first five instars the larval case was conical, constructed from brown silk with a papery texture and devoid of any plant material. From instar six, lengths of foliage were attached length-wise to the exterior of the cases. Their attachment

occurred in the anterior region and their ends projected as far as the posterior end of the case, often splaying out slightly. The amount of added plant material increased significantly with subsequent instars until finally some cases had the appearance of spiky galls or cones (Figures 2 and 3). At this stage cases could be easily sexed on the basis of their size, those containing females being much bigger than those containing males.

On emergence of the male moths (Table 2), their wings were covered with dark lanceolate scales. However, these scales were so loosely attached (deciduous) that they were lost during the insect's first flight (usually an hour or two, post emergence), leaving the wings almost completely transparent. These scales were preserved in-situ with some specimens by carefully removing the adults to a deep freezer prior to any scale loss. Having frozen them, they were carefully set, allowed to dry for a month then carefully removed from the boards. A paper shield was then cut and placed around the pin to cover the antennae, hairy thorax and abdomen. A light spray with artist's pastel fixative was then applied to the upper surfaces of the wings. This had the effect of fixing the deciduous scales without matting antennae or body hairs. This technique will probably work with other deciduous scaled Lepidoptera.

The eclosion of the first two males (the second one being crippled) could not be assigned even to a time interval, due to the erratic frequency of my observations at this time. Subsequently, the frequency of observations was increased and from the ensuing eclosion data (Table 2) it is clear that, where the precise emergence time is known (14 individuals with fully scaled wings), the majority (12) emerged during the afternoon to evening, i.e. between 13.30h and 20.30h (mean ~17.00h). Only on two occasions was male eclosion observed during the morning (07.10 and 08.00h), but these were exceptions to the norm.

This pattern of eclosion was seen by Morden and Waldbauer, in their paper on seasonal and daily emergence patterns of adult *Thyridopterix ephereraeformis* (*Entomological News* **82**:219-224, 1971), during their studies of seasonal and temporal emergence patterns of *T. ephemeraeformis*. One of their experiments, carried out in Champaign County, central Illinois, used field-collected populations of larvae from a *Juniperis virginiana* shrub. These they held under natural conditions of photoperiod and temperature, and observed that 90% of male eclosions (169, n=185) took place during the afternoon (noon to 18.00h). This would appear to demonstrate the important influence of photoperiodicity on eclosion time. However, additional experiments (Morden and Waldbauer *loc. cit.*) with populations maintained under artificial photoperiods (16-h lighr/8-h dark vs 50/50 light/dark) and constant temperatures (25°C vs 29°C) showed no link between eclosion and photoperiod; eclosions occurred with the same frequency throughout the day with both groups. Thus, they concluded that a certain minimum temperature was required for male eclosion to occur, and surmised that this was around 18°C and above. However, they pointed out that they had not conclusively demonstrated this.

For those males where emergence reported here could only be assigned to a time interval (13), at least six emerged during the evening, with another seven emerging

sometime during an extended period from the morning to the evening. Of those in the latter group, it is probable that the majority emerged later in the day rather than earlier, as five had wings that were scale-less but not worn, indicating eclosion within the previous 2 hours or so. The remaining two had worn their wings to stubs, indicative of eclosion some considerable time earlier.

Table 2. Eclosion data for male *T. ephemeraeformis* (n = 29)

Date	Time	Date	Time
1 Aug.*	by 16.00	20 Aug.*	16.00 - 18.10
4 Aug.* §	by 16.00	20 Aug.**	16.00 - 18.10
8 Aug.+	08.00	21 Aug.*	15.00 - 17.30
12 Aug.*	13.00 - 17.00 (n = 2)	21 Aug.*	17.30 - 22.10
13 Aug*	08.30 - 16.30 (n = 3)	22 Aug.+	07.10
16 Aug.+	15.30	22 Aug.*	08.45 - 15.30
16 Aug. +	15.45	23 Aug.+	17.00
16 Aug.+	17.00	24 Aug.+	13.40
17 Aug.+	14.10	24 Aug.+	19.00
17 Aug.	15.50	25 Aug.+	18.05
18 Aug.**	08.00 - 17.10	26 Aug.+	08.00 17.20
18 Aug.+	20.30	26 Aug.*	08.00 - 17.20
19 Aug.**	08.40 - 17.10	27 Aug.+	17.00

+ = fully scaled wings, indicating fresh emergence

* = wings devoid of scales, indicating emergence during the previous two hours

** = wings battered, so emergence occurred earlier rather than later during the time interval

§ = fore wing deformed due to injury of pupa during premature opening of pupal case

With the females it is harder to say with certainty the times when eclosion occurred (Table 3), on account of their concealed habit. The vermiform females of this species do not leave their pupal exuvia until oviposition is complete, and even then rarely leave their bags, making close observation of eclosion times difficult. Indeed, Moeden and Waldbauer (*loc. cit.*) did not consider female emergence periodicity for this very reason. On "emergence" females split their pupal case in three places behind the head plate, and project only their head and thoracic segment out of their pupa. Hence there is a point at which eclosion can be said to have occurred, even though the bulk of the female's body remains within its pupa.

As part of my containment plan, pairing was prevented by isolating pupae. This enabled female emergence to be observed by carefully cutting the female cases length-wise to expose the pupae within. By this means, limited data (Table 3) were

gathered which indicated a lack of periodicity in the emergence of this sex, although this conclusion is somewhat tentative due to the small sample size where emergence time could be identified (n=10) compared with the larger male sample size (n=18). This procedure was used after 16 August, when 11 emerged females were found by opening the female pupal cases. These had hatched some time before this date, most probably several days earlier.

Table 3. Eclosion data for female *T. ephemeraeformis* (n = 29)

Date	Time
16 Aug.+	12.00 (n = 11)
18 Aug.	02.00 - 08.30
19 Aug.	08.40 - 17.10 (n = 4)
20 Aug.	02.00 - 07.30
21 Aug.	08.00 - 22.10 (n = 3)
22 - 23 Aug.	22.10 - 00.40
23 Aug.	19.55 - 20.35
24 Aug.	16.10 - 17.35 (n = 2)
25 Aug.	15.00
26 Aug.	17.20
29 Aug.	02.30
31 Aug.	00.20
9 Sep.	08.10

+ females extracted from cases may have hatched several days previous to this date.

Emerged females were found to have shed large amounts of short yellow-coloured hair scales at their anterior and posterior ends. In an attempt to preserve as much of this material in-situ as possible, freshly emerged females were killed by freezing while still within their pupal exuviae. These were then pinned directly through the pupal shell and dried in a low oven for five or six hours. The pupal shell was then fractured and removed piece by piece from around the dried female. In this way the anterior yellow hair scales were found attached ventrally to the vestigial leg buds of the female, while the posterior hair scales were retained as a brush-like structure around the ovipositor. In the normal course of events these scales are lost due to therepeated movements of the female abrading them against the inside of the larval bag (anterior scales) and pupal shell (posterior scales). Their presence in this form (loose) may aid penetration of the bag and pupa by the male when pairing occurs.

In conclusion, it appears that day length and photoperiod may be important cues for male eclosion in *T. ephemeraeformis* (although the work of Morden and Waldbauer casts some doubt on this, emphasising the role of temperature). These

factors appear to be less important for female eclosion. If day length and photoperiod are important environmental cues for male eclosion it should be possible to predict the date and time of emergence for male *T. ephemeraeformis* in their native Missouri habitat. The male eclosions described here took place in Reading, which is at approximately 51.5° latitude, 0° longitude, while the Lake of the Ozarks is at approximately 38° latitude, 93° longitude. Using the GraphDark software package it can be seen that the average time of male emergence in Reading, 17.00-h, is 2.5-h before the onset of astronomical twilight on the mean date of male emergence (13th August). At Laure, Missouri, the onset of astronomical twilight occurs at 18.00-h on this date. Assuming that male emergence also occurs 2.5-h before the onset of astronomical twilight at this locality too, it is predicted that the main period of male eclosion should be around 15.30-h during mid August at the Lake of the Ozarks. It may be coincidental that this is almost midway between the emergence times for males observed by Morden and Waldbauer, who gave a range of 12.00 – 18.00h for male emergence of a field population commencing on 15th September in Champaign County, Illinois (40° latitude, 89° longitude).

Figure 1. Final instar larva of *Thyridopterix ephemeraeformis* showing three large dark markings on lateral side of pro-thorax, arranged triangularly.

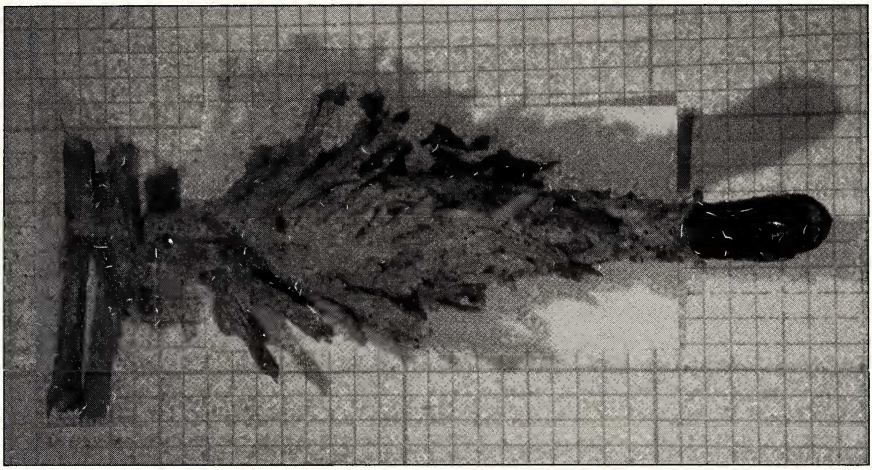

Figure 2. Male case of *Thyridopterix ephemeraeformis.*
(Grid squares = 2/2mm, i.e. 4mm^2)

Figure 3. Female case of *Thyridopterix ephemeraeformis.*
(Grid squares = 2/2mm, i.e. 4mm^2)

Of course, these data shed no light on the role that temperature plays in the date and timing of male eclosion with this species as, regretfully, temperature data were not recorded. However, temperature has been found to be less important than photoperiod in influencing eclosion date and time with some of the lower Psychidae (Sims, *Ent. Rec.* **12** 29-30, *Br. J. Ent & N. H.* **12** 17-25, *Br. J. Ent & N. H.* **15** 71-78).

The concept of Growing Degree-Days (GDD), as outlined by the Cornell Cooperative Extension (www.cce.cornell.edu/suffolk/grownet/ipm/gdd.html), for insect pest management is of interest in this respect as it relates larval development to temperature. For every °F that the mean daily temperature between 1 March and 30 September is above 50, one GDD is accrued. For example, if the average of the minimum and maximum temperature on one day during this period is 55°F, 5 GDDs are added to the accrued total. The aim is to enable horticulturalists to estimate the most appropriate timing for pest control procedures (pesticide application). With *T. ephemeraeformis*, they recommend taking precautions between 600 and 900 GDDs. Although not of immediate relevance to the timing of male eclosion, this demonstrates that predictions can be made regarding larval development rates, based on the influence that temperature has on larval development of this insect.– Ian Sims, 2 The Delph, Lower Earley, Reading, Berkshire. RG6 3AN.

***Biston strataria* Hufn. (Lep.: Geometridae): Melanic forms in north-west Kent**

On 19 March 2005, a melanic *Biston strataria* was found at my garden m.v. light at Dartford. The pale areas present in normal specimens are obscured by dark scaling; it was identified as ab. *robiniaria* Frings. Chalmers-Hunt (1976. The Butterflies and Moths of Kent, *Suppl. Ent. Rec* . **88**: 156) mentions several specimens from East Kent (VC 15), but none from West Kent (VC 16). The aberration is depicted in Ford (1955. *Moths*. Plate 8.4). It would appear to be comparatively rare in Britain; it is quite distinct from the more extreme melanic ab. *melanaria* Koch, uniformly black and resembling ab. *carbonaria* Jordan of *B. betularia* L., which has become common in Holland, but here remains known from but two or three specimens.

Thus there has been considerable resistance to the development of industrial melanism in Britain in this species. However, in north-west Kent until very recently many specimens have displayed a tendency towards melanistic development by the white areas becoming sullied by dark scaling to a varying degree. Thus, ab. *intermedia* Lempke might be regarded as a melanistic form representing a half-way stage to ab. *robiniaria* with its somewhat darkened white areas. It has been a not uncommon variety here, but no longer so. I have two specimens dated Eynsford 14.iii.1961 and Dartford 2.iv.1995. Chalmers-Hunt (*op. cit.*) does not mention this form as occurring in Kent. It is important to note that such specimens are not heterozygotes for ab. *robiniaria* which in fact are very similar to the homozygotes (note appended to a long series of bred ab, *robiniaria* in the National Collection).— B. K. West, 36 Briar Road, Dartford, Kent. DAS 2HN.